Oil refining in Mexico and prospects for the Energy Reform

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Abstract:

This paper analyzes the conditions facing the oil refining industry in Mexico and the factors that shaped its overhaul in the context of the 2013 Energy Reform. To do so, the paper examines the main challenges that refining companies must tackle to stay in the market, evaluating the specific cases of the United States and Canada. Similarly, it offers a diagnosis of refining in Mexico, identifying its principal determinants in order to, finally, analyze its prospects, considering the role of private initiatives in the open market, as well as Petróleos Mexicanos (Pemex), as a placeholder in those areas where private enterprises do not participate.

Key Words: Oil, refining, Energy Reform, global market, energy consumption, investment

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INTRODUCTION

At the end of 2013, the refining market was one of stark contrasts. On the one hand, the supply of heavy products in the domestic market proved adequate, with excessive volumes of fuel oil. On the other, the gas and diesel oil demand could not be met with production by Petróleos Mexicanos (Pemex). The possibility to expand the infrastructure was jeopardized, as the new refinery project in Tula, Hidalgo was put on hold and the plan was made to

retrofit the units in Tula, Salamanca, and Salina Cruz. This situation constrained Pemex's supply capacity in subsequent years and made the country reliant on imports to supply the domestic market.

In this context, the choice was made to liberalize the refining industry, aiming to revive it. However, these efforts were ailed b a series of challenges, which will be the topic of analysis in this paper, and will be essential to the behavior of the industry for years to come. This paper begins with a first section to offer general considerations about the global refining industry, followed by a second section that examines its performance in the American and Canadian markets, taking into account that more of the companies that may or may not have business relationships in Mexico, they also conduct operations in their own nations. The third section introduces a diagnosis of refining in Mexico, based on industrial analysis tools throughout the entire value chain to, finally, identify the top challenges looming ahead in the new scenario of open-market competition.

THE REFINING INDUSTRY AROUND THE WORLD

The refining industry is strategic for the economy, as it is an opportunity to add value to oil. Its distillates are the foundation to supply countless activities in which human beings engage, including, most notably, transportation, power generation, and activities that require heat.

In general, the refining industry is capital-intensive, and size and technological complexity, as well as wage costs and environmental regulations, are all relevant to its viability. The industry is composed of a set of large continuous production plants, where crude oil is separated into different fractions; for example, oil is physically and chemically processed to produce finished products, which range from very light—like liquefied petroleum gas—to the heaviest—like asphalt or petroleum coke. The refining industry also encompasses the transportation and storage of processed products, as well as delivery to consumers through distribution points.

In response to market conditions, the refining industry has gone through various stages, such as surplus production capacity at the end of the 1980s and the beginning of the 1990s, or plummeting profit margins in the early years of the past decade.

In general, the international refining industry continues to reinvent itself, whether by expanding capacity, renovating and/or upgrading it, in order to expand its useful life and competitiveness, with processes aimed at higher value added products, like gasoline and diesel, and limiting the production of heavy byproducts; or the use of flexible technology to process crude oil in light of problems with disposal at refineries and price volatility.

The industry has also faced very narrow and volatile refining margins that have driven up operational efficiency, as well as actions to optimize the energy used, automate processes, and hire highly skilled staff, among other measures. Efforts have been made to supply the type of oil byproducts for which the market is most hungry: cleaner, more efficient, and up to required quality standards; as well as to adapt to the trend of coexisting alongside substitute fuels,[2] like natural gas in the United States, adopt environmental standards into processes, which in some cases require investments that will yield little by way of returns; to process higher quality byproducts in combustion, through the incorporation of better technologies, such as is the case of gasoline with a higher enthalpy of evaporation, which makes it more efficient by cooling the fuel mix during the injection process, or simply through a mix of liquefied products obtained from renewable sources, like ethanol.

Likewise, in light of the long-term returns, refining companies have sought schemes to access financing by turning to the stock market or bank loans, but also by capitalizing on their profits derived from times past when oil prices were higher, as they were between 2004 and the end of 2014.

In particular, strategies have been implemented to improve the positioning of refining companies in the market. Along these lines, the international oil companies are standout examples. In addition to earning significant profits in the refining business, they have robust processing, storage, and transportation systems for petroleum-based products and even, in some cases, have upstream integration in their activities, or may focus on only on refining.

The refining business operates in a free market world, even in those cases where the government intervenes. In the latter cases, some units barely manage to break even or may lose money.

At close of 2014, total demand for oil byproducts hit 92 million barrels a day (mmbd), of which 49% went to countries in the Organization for Economic Cooperation and Development (OECD), which displayed a downward trend of nearly 3 mmbd since 2008 due to the effect of the economic shakeup. Fuel oil consumption suffered the most. By

[2] The natural gas production boom has created jobs, especially in the transportation sector. There is also production of other liquefied fuels, such as biofuels, gas to liquid, or coal to liquid.

contrast, in non-OECD nations, the demand for petroleum products has grown stronger (see Table 1).

Table 1. Demand for Petroleum Products in the World 1980 and 2014

Petroleum Byproducts	*Europe and Japan*		*Asia Pacific*		*North America*		*Rest of the World*	
	1980	*2014*	*1980*	*2014*	*1980*	*2014*	*1980*	*2014*
Light distillates	4.7	4.4	2.0	10.0	8.1	10.8	2.3	4.9
Intermediate distillates	6.7	8.7	3.2	11.0	5.1	6.8	4.2	7.4
Fuel oil	6.1	1.4	3.8	2.8	2.9	0.4	2.5	3.3
Other	3.0	3.6	1.5	7.1	3.8	5.3	1.3	4.1
Total	20.5	18.1	10.5	30.9	20.0	23.3	10.2	19.8

Source: BP (2015).

On the other hand, global refining capacity at the end of 2014 was higher than the demand for petroleum products, at 96.5 mmbd,[3] 22% above what it was in 1980, and it was non-OECD countries that saw the highest increase. The Asia-Pacific region stands out, as well as a trend in the Middle East to add value to crude, not to mention the greater installed capacity they have achieved. This stands in sharp contrast to Europe, where said capacity fell by 4.5 mmbd between 2008 and mid-2014 (IEA, 2014).

Between 1980 and 2014, the refining capacity in North America declined, as did its contribution to the world total (see Table 2). As 2014 drew to a close, it was 21.3 mmbd, of which the United States accounted for 84%, Canada 9.2%, and Mexico the remaining 6.8%. The net volume of oil imported in that region amounted to a little more than 4.6 mmbd, basically due to purchases from outside the United States, which, thanks to its surpluses, made the region a net petroleum exporter.

Table 2. Global Primary Distillation Capacity. Thousands of barrels per day

Region/country	*1980*		*2014*		*1980-2014*	
	No.	*Participation*	*No.*	*Participation*	*No.*	*Participation*

[3] At year-end 2013, the total number of plants operating in the world was more than 12,000 units.

United States	18 620	23.5%	17 791	18.4%	-829	-4.5%
Canada	2 155	2.7%	1 965	2.0%	-189	-8.8%
Mexico	1 207	1.5%	1 522	1.6%	315	26.1%
Total North America	*21 982*	*27.8%*	*21 278*	*22.0%*	*-704*	*-3.2%*
Asia Pacific	12 364	15.6%	32 461	33.6%	20 097	162.5%
Europe and Euro-Asia	31 911	40.3%	23 724	24.6%	-8 187	-25.7%
Middle East	3 528	4.5%	9 428	9.8%	5 900	167.2%
Africa	2 073	2.6%	3 553	3.7%	1 480	71.4%
Central and South America	7 251	9.2%	6 069	6.3%	-1 182	-16.3%
World total	79 109	100.0%	96 514	100.0%	17 405	22.0%

Source: Created by the author with data from BP (2015).

The Organization of Petroleum Exporting Countries (OPEC) estimates that 9 mmbd of primary distillation capacity will be added between 2014 and 2019, of which more than 92% will be derived from upgrades and expansions to existing plants, and the remaining 8% will be new capacity, and it is the Asian region that should show the strongest growth. Investments in the global refining industry could climb as high as 102.1 mmbd in 2020 (IEA, 2015). To do so, companies must tackle the challenge of evaluating the operational models they have chosen and their levels of integration, particularly in North America and Western Europe (Atkearney, 2012).

In the coming years, the international refining industry will continue to add technological advances, in particular, bringing about more efficient and flexible processes to produce byproducts and energy savers, better coupled with petrochemical plants, and preventing greenhouse gas emissions; the benchmark is higher energy efficiency. The automotive sector is noteworthy in this sense, expecting to achieve performance of nearly 20km/liter by 2025 (The White House, 2012).

However, one crucial factor to the future of refining is associated with how investment decisions are changing in response to the behavior of international oil prices.

THE UNITED STATES

In 2014, the United States consumed an average of 19.0 mmbd, continuing along the downward trend that began in the early years of this decade, especially when it comes to light petroleum products (gas and diesel). The prices of these products are determined by the market conditions that drive companies to operate pursuant to their own efficiency criteria.

As of the end of 2014, the United States had 142 refineries, which represented a drop of 53% as compared to 1982, of which 139 were operating and three were not. The number of refineries shrunk by virtue of technological obsolescence and falling profitability, but operable refining capacity rose by 13.4%, which was reflected in a jump in average productivity per refinery, which more than doubled.[4] In particular, the capacity of coking plants rose—to triple over 1980—, as well as that of desulphurization and diesel production.[5] Large refineries have not been built since the 1970s, but a few new smaller capacity plants have been added.[6]

Installed capacity reached 17.8 mmbd, the majority of which came from refineries processing less than 100,000 barrels per day (mbd), and one-fourth of which came from those with capacities higher than 250 mbd. The refining market structure in the United States is the result of mergers and acquisitions,[7] giving it the profile of a sort of monopolistic competition. ExxonMobil alone controls 10% of total refining capacity, and the top five companies together account for 43% of said capacity (Chesnes, 2015).

Refinery operation has tended to improve over time, as they optimize production and downtimes for maintenance, and utilization capacity has risen, averaging nearly 89% between 2004 and 2014. To the strategy of operational improvement has been added the availability of lower-priced light crude,[8] but there is still a need to import heavy petroleum to supply the Mexico Gulf Coast refineries, where there is a more articulated crude and petroleum product market.

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[4] Investments have been made in projects to expand the capacity of, replace, and upgrade plants, as well as to add new catalyzers or improve processes and drive greater energy efficiency.

[5] The average production of low value added products (fuel oil, asphalt, and petroleum coke) was nearly 10% between January and October 2015, which compares with a little over 13% recorded at the beginning of the 1990s.

[6] In 2015, Buckeye Partners Corpus Christi, TX (46 mbd), Petromax Refining (25 mbd), and Dakota Prairie (19 mbd) commenced operations, while Kinder Morgan Refinery expanded (84 mbd). In 2008, there was another capacity increase at Interline Resources Refinery (4 mbd), as well as other projects (EIA, 2016).

[7] As of the end of the 1990s, 40 companies had refineries, but by the end of 2013, this number had fallen to a little over half (EIA, 2013).

[8] The quality of crude processed by the refineries average 30.4° API at year-end 2014, but its sulfur content rose, which has obliged the continued importation of heavy crude.

Although the United States is a net buy of oil that it can sell abroad,[9] imports of petroleum byproducts domestically have displayed a downward trend, going from a high of 3.5 mmbd in 2005 to 1.9 mmbd in 2014. Its top suppliers are: Canada (26.6%) and Russia (16.4%). On the contrary, exports of these products grew from 0.855 mmbd in 1995 to 3.8 mmbd in 2014, with the leading destinations as Central and South American (34%), Europe (22%), Mexico (16%), Canada (8%), Africa (4%), and the Middle East (2%).

One of the strengths of refinery development in the United States and the country's trade abroad has been the existence of infrastructure for transport.[10] Some American refineries capitalize on accessing the light crude extracted from their facilities as a competitive advantage, especially in the market of petroleum to be processed.

CANADA

In Canada, the refining industry is an important boon to the economy, having contributed 4% of the Gross Domestic Product (GDP) in 2013, and employing over 18,000 people with competitive wages (Canadian Fuels Association, 2014). Since 1970, the country has undergone a restructuring process, which has led to the closure of more than 20 refineries, although others were expanded or upgraded, but no new refinery has been built since 1984. At the end of 2014, Canada had 15 refineries with installed capacity of 1.9 mmbd. Some plants are more than three decades old and produce a high percentage of fuel oil (20% of total processed products), which means they have low efficiency levels. The country is in the process of building a refinery in Sturgeon County, Edmonton,[11] which is expected to begin operating in 2017, and will be able to sequester Carbon Dioxide (CO2), which will be injected into oil fields.

[9] The United States lifted the prohibition on exporting crude in December 2015, after more than 40 years of maintaining this provision in place through the Energy Policy and Conservation Act.

[10] The United States has a complex system of secure, rapid, and efficient pipelines, extending over 307,000 kilometers, and a robust railway transport system, particularly for the refineries in the east, which is complemented by vehicle transport.

[11] First-phase investment in the Sturgeon refinery was around 11 billion dollars and will process 79 mbd of diluted bitumen and shall produce ultra-low-sulfur products, among others

The vast majority of the petroleum product supply is handled by three companies (Shell, PetroCanada, and Imperial Oil), and a handful of regional companies (Irving Oil, Ultramar, Suncor Energy, Federated Co-op, Husky, and Chevron), the majority Canadian- and American-owned. Canada has plants that use petroleum as an input to produce asphalt products, petrochemical plants, and so-called upgraders, which, besides transforming heavy into light crude, also produce diesel. With scant exceptions, finished products are distributed by the companies themselves.

Canada is a net oil exporter,[12] and its petroleum imports account for around 12% of consumption, the majority from the United States (Natural Resources Canada, 2014), especially due to logistics reasons, as there are surpluses in the East and scarcity in the West of the country.[13]

Processed petroleum is in large part light crude, but also the synthetic obtained from tar sands, which is vulnerable to following oil prices, as it faces production costs of at minimum 40 dollars a barrel. As one of the leading car producing countries in the world, the Canadian refining industry has been focused on fuel quality, in particular on reducing sulfur levels in gasoline (90%) and diesel (97%). The country is also using alternative energies, as gasoline contains around 5% and diesel 2% of biofuels (Canadian Fuels Association, 2015).

REFINING PERFORMANCE IN MEXICO

The refining industry in Mexico has been the cornerstone of the country's economic growth, as it is able to provide fuels and inputs in a timely fashion, mainly to the transportation sector. Thanks to its development, Pemex was ranked among the top 15 companies in terms of refining capacity in the world in 2014. Pemex's subsidiary, which managed the refining operations, was known as Pemex Refining (PR), but starting in 2015, it was merged into Pemex Transformation.

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[12] Net crude oil exports from Canada amounted to 2.4 mmbd in 2014; of total exports, nearly half were synthetic oil and bitumen. Of the total of petroleum byproducts produced, more than one-fourth was exported, mainly to the United States.

[13] The Canadian refining industry has ample availability of crude and infrastructure for processing on the East coast, but must import in the West, as well as having to confront American competition in the region.

After the oil boom, which helped the industry achieve major technological advances through the Mexican Oil Institute, transcending borders with such products as the DEMEX process, refining in Mexico began to face a dearth of investment resources to upgrade and grow, starting in the 1980s, but especially since the oil policy began to focus on developing the supergiant field Cantarell.

Average annual investment rose to 0.71 billion dollars (bd) between 1991 and 1999. This resulted in insufficient maintenance, constraints on incorporating technology, operational improvements, and failure to increase installed capacity. Moreover, units were closed in Azcapotzalco, Poza Rica, and Reynosa at the beginning of the 1990s.

The program to reshape the National Refining System (SNR) was authorized at the end of the 1990s and involved building new processing plants, as well as expanding and upgrading those already existing. Investment amounted to nearly two billion dollars annual average between 2000 and 2001, to develop works at the Cadereyta and Madero refineries, and later fell to 0.66 bd between 2002 and 205. Starting in 2006, new resources were injected, averaging around 1.9 bd per year until 2014. Some notable projects included the Fuel Quality project and the retrofitting of Minatitlán (see Table 3). In this way, the refineries in Cadereyta, Madero, and Minatitlán culminated the retrofits and raised the volume processed of heavy crude petroleum from 15.0, 11,0, and 122.9%, respectively, as fuel oil production fell to 48.6%, 64.9%, and 69.4% (ASF, 2014).

Table 3. Investment in Refining, 2006-2014. Millions of dollars

Project	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*
Fuel Quality	-	-	-	32	268	470	504	214	531
Salamanca Residual Conversion	-	-	-	8	5	6	12	70	89
Tula Retrofit	-	-	-	-	-	-	-	-	73
New Tula Refinery	-	-	-	3	11	4	34	398	32
Tuxpan and SDT Pipeline	-	-	-	48	67	55	46	20	19
Minatatlán Retrofit	764	847	639	382	375	204	412	-	-
Other	627	615	913	899	1 106	1 060	1 216	1 577	1 958
Total	1 391	1 462	1 552	1 371	1 832	1 798	2 225	2 278	2 702

Note: SDT: Storage and Distribution Terminal. **Source:** Pemex F-20.

At close of 2014, Pemex had six SNR units with installed processing capacity of 1.6 bd, only 2.8% higher than what it had in the year 2000, but 5% lower than in 1990.[14] Moreover, it held 50% of Deer Park's shares, which is operated by Royal Dutch Shell, and which controls the other half of ownership.

The refinery management strategy, which has entailed not building a new unit since 19779, has led to exporting the crude extracted abroad, rather than processing it. The United States Gulf Coast is one of the top destinations, from which a significant portion of imported petroleum products are obtained.

In general, this landscape reveals that refining in Mexico is facing a complex situation, derived from its reliance on public funding,[15] and a set of factors tied to its development throughout the entire value chain. The most relevant are:

- The types of crude petroleum supplied by Pemex Exploration and Production (PEP) do not meet the technical considerations required for the configuration of the refineries, which were designed to process light crude, which leads to difficulties when it comes to feeding them the right mix of crude.[16] To this is added that the prices of crude acquired from Pemex PEP are done by international reference, which limits the relative advantages an integrated company might enjoy.
- In operating the refineries, there are problems that restrict their profitability, such as: low level of usage of installed capacity, due to unscheduled shutdowns and technical problems,[17] in stark contrast with neighboring countries in North America and other Asian nations (see Figure 1). This led to a fall in the volume of crude processed in the SNR, and, as such, that of refined products; energy consumption also began to rise,[18] although it would fall partially with the advent of cogeneration

[14] The hydrosulfuration, alkylation, and isomerization and coking plant capacities have risen, but the capacity of the vacuum distillation, catalytic cracking, and viscosity reduction plants has fallen.
[15] Investment spending on refining has fallen numerous times since the 1980s, but one of the most recent drops occurred with the projects contracted in 2014, which would be built in periods of between three and 3.5 years. They were deferred in February 2015, with cutback of 11.5% on the Pemex budget.
[16] The problems to obtain an adequate mix to feed the refineries led to the need to exchange heavy crude for light with the United States in 2015.
[17] Some of the main problems with unscheduled shutdowns included high levels of fuel oil inventory, problems in crude supply, electrical power failures, not to mention accidents at some plants, like the accident in Tula with the viscosity-reducer plant in 2011.
[18] The six Mexican refineries use 43% more energy than the international industry standard for refining (IMCO, 2013).

projects in the Salina Cruz, Tula, and Cadereyta refineries;[19] there was also a failure to update the technologies used in the equipment and processes, which is a constraint on the capacity to process qualities of crude with high sulfur and metal content, which is what is available in the country; refineries have also seen low yields on products of high value in the market and surplus production of fuel oil, which cannot be sold in the national market due to quality problems and the trend to use natural gas in power generation rather than the fuel.

Source: BP.

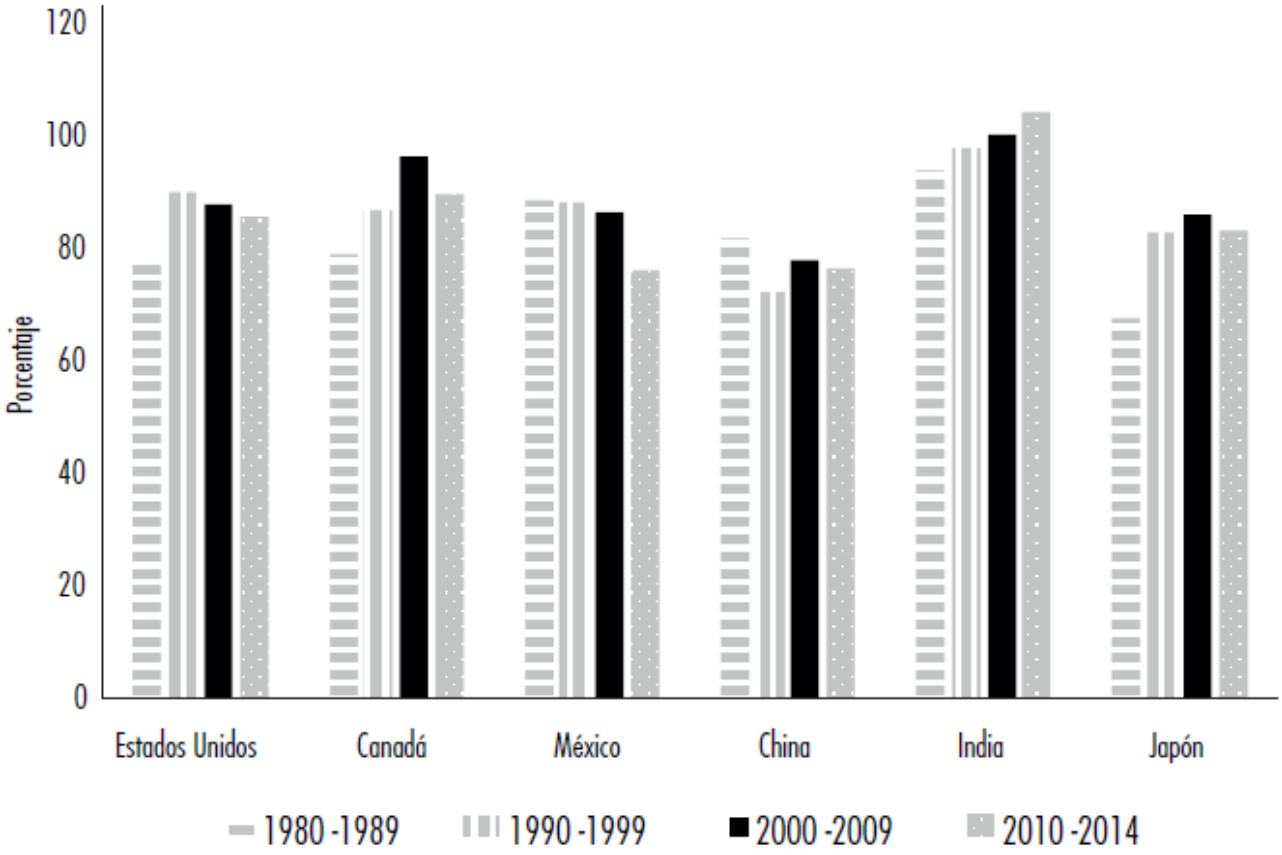

Figure 1. Usage of Installed Capacity in Select Nations

[19] Projects in development in the Salina Cruz, Tula, and Cadereyta refineries have a capacity of 16383 megawatts/hour and steam of 3,050 tons per hour, with forecast investment, alongside the Cactus Gas Processing Complex, in Chiapas, of approximately three billion dollars, of which a large part will come from private initiative (Pemex, 2015a).

- In spite of the clean fuel program, PR has not managed to meet the targets set in NOM 086,[20] because it does not have the financial resources to build the infrastructure needed to do so, which leads to a loss in competitiveness for the fuels processed in the North American market. To the foregoing are added the challenges that the government has taken on when it comes to climate change,[21] which it aims confront with the Climate Action Plan.
- At the management level, there are obstacles in implemented the strategies and programs chosen in a way that would bring about operational improvement, as was the case of the Operational Performance Improvement Program (PMDO) after the 2008 energy reform,[22] bureaucracy is one barrier, because it makes decision-making very slow, both due to the organizational structure that has emerged over the years as well as overstaffing at PR,[23] as compared to other companies in the same sector, which results in low productivity in sales per employee. Much of this situation is attributable to the negotiating power of the Oil Workers Union in Mexico, which does not limit itself merely to labor representation but rather deals with a wide range of special interests involved in PR's activities.[24]
- Inability to execute PRs investments, because the company's plans have not been funded on time or in the right way in the majority of cases. One example of this was the delay in the projects to retrofit the Cadereyta and Minatitlán refineries, which led to incurring non-productive expenses. But the most significant case was the failed new refinery project in Tula,[25] for which a little over 480 million dollars was spent, and it was argued that many of the jobs would be taken up again in the refinery operating there.

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[20] According to NOM 086, Pemex should have supplied magna 30 gas on average and with 80 ppm maximum of sulfur and diesel and 15 ppm maximum of sulfur starting in January 2009 in the entire country and it still has not done it.

[21] In the framework of the Global Climate Change Summit (COP21) held in Paris, Mexico committed to reducing greenhouse gas effects by investing in the refining industry.

[22] In 2010, the Operational Performance Improvement Program (MDO) was launched for the Madero and Salina Cruz refineries and, in 2011, in Tula, Cadereyta, Salamanca, and Minatitlán, but with rather unsatisfactory results. Between 2010 and 2013, Pemex Refinación reported an average real rise of 3.9% in transportation and distribution costs, 0.4% in administration, in contrast with a reduction in sales costs of 3.9%, which was more associated to the 4.1% decline in oil prices.

[23] Pemex Refinación had 47,576 employees at the end of 2014, 31% of overall Pemex, but in 2004, it reduced its payroll to 44,899 people, down from the 48,867 who worked there in 1994.

[24] Rodrigo Olvera Briseño, from the Center for Labor Reflection and Action (Cereal), said that "it is pretty well known that the managers of refineries or work centers create outsourcing companies that belong to them and then award themselves the work contracts that Pemex workers have to do" (*Revista Contralínea,* 2013).

[25] The proposal approved by the Congress for the new refinery, which would enter into operation in 2015 with a capacity of 300,000 barrels a day, demonstrated that it was possible to earn annual profits of three bd a year, on estimated costs of nine bd (González, 2013).

- Insufficient capacity to store crude in refineries and distillates at the Storage and Distribution Terminals, which led to saturation problems along some of the transport lines,[26] mainly in the center of the country when there are failures or unforeseen events, for example, fuel theft, or fuel leak accidents- This alongside the less than optimal use of pipelines and poly-pipeline infrastructure, technology lagging, and an average age of over 25 years.
- A serious problem facing the PR is the failure to detect fuel theft[27] and the growth of the illicit fuels market.[28] In the former case, the problem has been accompanied by frequent leaks and spills, some of very large magnitude, like the case of San Martín Texmelucan, Puebla, in 2010, as well as those that take place as part of the company's daily operations.
- In spite of the investments made in the Clean Fuels project, the company has yet to comply with the standard to reduce the sulfur content of gasoline and diesel, as the requirements have only been met for a few of the major metropolitan areas in the country.
- The Mexican refining industry trails others when it comes to technology and dependence, as interest in IDT has faded since the mid-1980s. Neither Pemex nor the IMP have allocated sufficient financial resources, and even less so in an environment where infrastructure projects have faced limitations, which, in turn, means that the researchers needed to for current technological challenges have not been trained.
- PR's mechanism for gas and diesel distribution has expanded over time,[29] and been enhanced with the supply of complementary services (convenience stores or auxiliary services), but they face an image issue, as service stations do not always provide "liters that are really a liter" and in some cases dispense products obtained from the illicit market or are located in inadequate locations for operations, for example, hospitals or areas where people gather.
- The limited capacity of consumers leads to a supply of products with quality problems. Between 2004 and 2013, the amount of the domestic demand for the top

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[26] Mexico has only 5,313 kilometers of oil pipelines and 8,946 kilometers of poly-pipelines, mainly distributed throughout the center-north and Gulf of Mexico. Petroleum is transported through pipelines (66%), tanker ships (15%), train (5%), and the rest by vehicle transportation. In particular, transportation from the Storage and Distribution Terminals to distribution at points to dispense it to the public is done through vehicle tanks (Secretaría de Energia, 2016).

[27] In 2014, authorities identified and shut down 4,125 illicit connections for fuel theft, a figure that was 43.7% higher than the 2,871 detected in 2013. The state of Tamaulipas had the highest number of cases (641), accounting for 16% of the national total of PR's pipelines, followed by Guanajuato, with 524 (13%), Sinaloa with 519 (13%), and Jalisco with 359 (9%) (Pemex, 2015b).

[28] Of the over 800 mbd of fuel produced in Mexico, 27 mbd are lost due to crimes such as theft (*Mundo Ejecutivo Express,* 2015).

[29] At year-end 2014, there were 10,830 Pemex service stations, of which 10,783 were franchises and the rest were operated by PR (47). This is more than triple the number recorded in 1990 and more than double the number in year 2000.

petroleum products (gasoline, diesel, and jet fuel) covered by national production fell from 82.3% to 63% (ASF, 2014).

- Refining in Mexico has traditionally not been a profitable business, because although PR's revenue has risen, it has recorded consecutive losses on the books every year since 1994, translating into negative equity of around 20 bd as of year-end 2014, which is rather atypical in the industry (see Table 4). The accumulated difficulties have been exacerbated because PR, and Pemex as a whole, has faced high leverage, liquidity problems, and low productivity.[30]

Table 4. Investments in Pemex Refinancing, 2006-2014. Thousands of barrels per day

Concept	*1990-1999*	*2000-2009*	*2010-2014*	*2014*
Refining capacity				
Atmospheric distillation	1 538	1 544	1 642	1 602
Vacuum distillation	751	764	804	768
Catalytic cracking Thermal	340	386	414	423
Viscosity Reduction	112	121	91	91
Catalytic craking	190	286	279	279
Naphtha reforming	644	926	1 056	1 068
Hydrosulfuration	71			
Fractioning of liquids		125	147	154

[30] From 2008 to 2014, PR reported negative equity, which led it to record leverage—total liabilities and total assets—of 1.5 times the last year of the time period. Moreover, between 2011 and 2014, it reported a negative liquidity indicator. This, alongside sales per employee far below international standards (see Table 4).

Alkylation and isomerization		88	145	156
Coking	1 292	1 271	1 186	1 155
Processing of crude oil and liquids in refinery	161	198	181	181
Cadereyta	147	139	123	111
Madero	185	169	166	168
Minatitlán	171	191	180	171
Salamanca	281	290	272	270
Salina Cruz	254	284	264	255
Tula	49%	38%	26%	34%
% of heavy crude processed	1 510	1 517	1 408	1 385
Processing of petroleum products	27%	29%	30%	30%
% gasoline	18%	20%	21%	21%
% diesel	5%	4%	4%	4%
% kerosene	1 498	1 746	1 777	1 709
Volume of domestic petroleum product sales	52%	59%	70%	72%
% gasoline, diesel, and kerosene	116	169	182	201
Volume of petroleum	49%	54%	41%	34%

product exports				
% gasoline, diesel, and kerosene	206	365	644	641
Volume of petroleum product imports	46%	54%	79%	80%
% gasoline, diesel, and kerosene	47 746	45 922	46 801	47 576
Number of employees at Pemex Refinación	35%	33%	31%	31%

Source: Created with data from the Energy Information System and Pemex.

In light of the budgetary constraints that the oil industry will likely be facing, both in light of the public sector's financial situation as well as the potential for low oil prices, at least until the end of this decade, reviving state refining would seem to be a complicated matter, especially considering the official projects planned.

PROSPECTS FOR REFINING IN MEXICO

Consumption of byproducts in Mexico has risen as a result of booming economic activity, but also due to the political decision not to develop other transportation alternatives, such as rail or public transport. On other occasions, low gasoline and diesel prices, as compared to international benchmarks, were a factor that drove up consumption, particularly up until the 1980s (Romo, 2011).

Pemex's flagging refining performance has forced the country into a position as a net petroleum product importer and, starting in 2015, it has displayed an oil trade balance

deficit, with gasoline as the main product acquired from abroad (see Figure 2). Mexico is now only a net exporter of fuel oil. In fact, nearly half of national apparent gasoline consumption needs to be imported. In other words, there is a captive market to be supplied, which, in 2014, was just over 350 mbd.

Source: Pemex F-20.

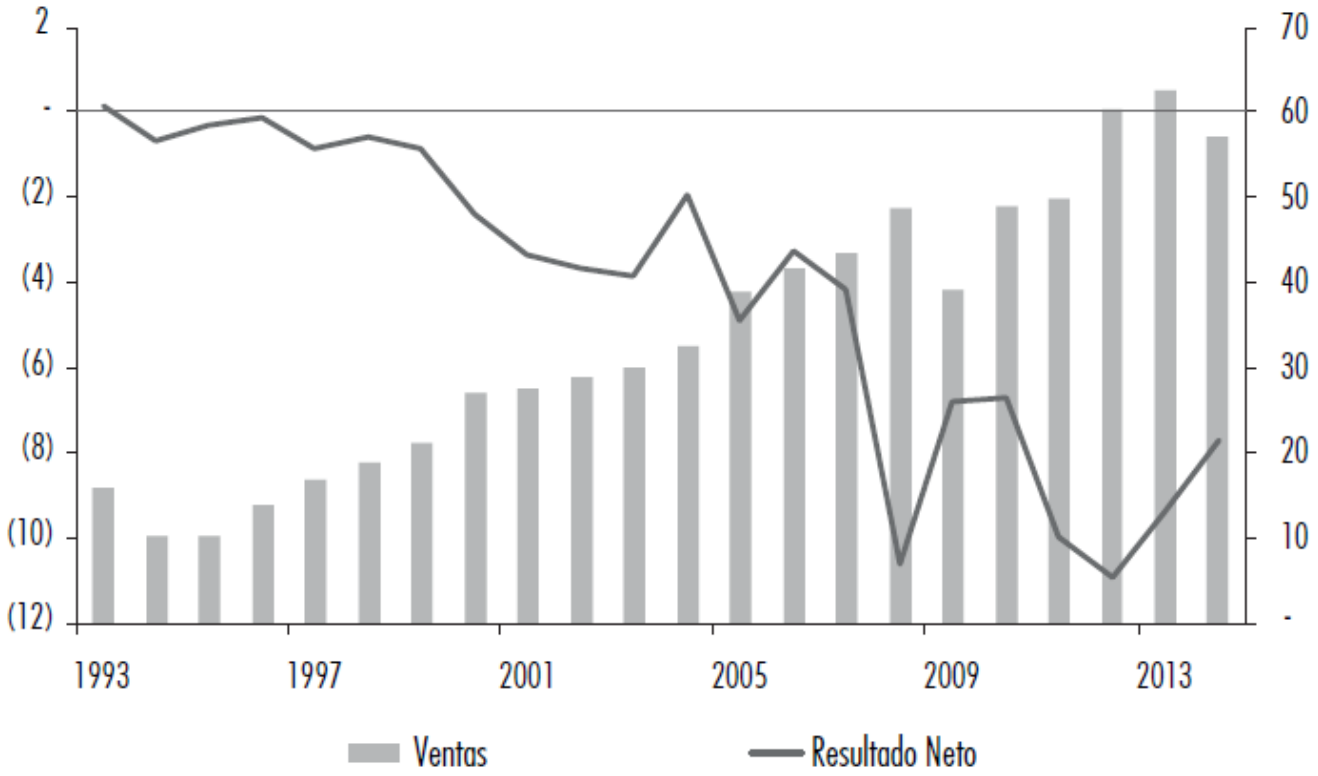

Figure 2. Net Results and Sales of Pemex Refinancing. Millions of dollars

Official estimates (Secretaría de Energía, 2014) signal that in 2028, the demand in Mexico will be nearly two mmbd of crude oil equivalent, 38% more than 2013 consumption.[31] Gasoline has the highest demand, followed by diesel, as a result of its intensive use in car transportation.

[31] By 2028, the transportation sector will have the highest demand for petroleum products (51.4% of global consumption), followed by industrial (17% of the total), and the electrical industry, which will display lower growth (31.2%). In 2013, shares in the total in each case were 46.8%, 13.8%, and 37.2%, respectively (Secretaría de Energía, 2014).

With the approval of the December 2013 energy reform, the government set conditions for public and private companies to treat and refine oil in the country, pursuant to a legal and fiscal regime,[32] that does allow for private enterprises to participate, with immediate deductions for investments.

In a market that will become competitive starting in 2018, and in which consumers do not have much capacity to influence, there is the potential to offer petroleum products processed in the country, and in the case of light crude, offer it in mixes with renewable fuels, like ethanol.

Mexico is a net exporter of crude oil, so it has enough volume for processing. The challenge will be for private enterprises that exploit it to gain the capacity to process it, although not all winning companies in Round One are dedicated to downstream activities.

Meeting the expected demand for refined products would entail implementing a series of actions, or some combination of them, as follows:

a) Reviving investment in Pemex, both to expand its current refining capacity as well as to create new capacity, which is complicated in light of the government's financial constraints, alongside a lack of political will.[33] In fact, the first order of business will be to deal with the delays in the projects to retrofit the three refineries (Tula, Salamanca, and Salina Cruz), channel additional resources to the Clean Fuels Project, and attend to the aforementioned commitments made by the government to international environmental standards.
b) Promote joint investments with the involvement of Pemex and private initiative, where the state enterprise's negotiating capacity would be based on the availability of infrastructure to use. There is also an alternative by which this refining infrastructure could be sold to private enterprises.
c) National private enterprises could build the new infrastructure required to expand the supply of petroleum.
d) Acquire what is missing from abroad through imports, for which it will be necessary to build the required transportation infrastructure to improve the

[32] The Ministry of Energy is entitled to grant permits for any company to invest in refining, as well as exporting and importing petroleum products. Special treatment has been given to diesel and gasoline, which private parties will be able to import starting in April 2016. On the other hand, the Energy Regulatory Commission is in charge of permits for transportation, storage, distribution, and dispensing hydrocarbons and petroleum products to the public. The preceding goes along with the independent oversight and supervision of regulatory compliance applicable to each of these institutions.

[33] One example of a public policy to stimulate refining is found in India, where the Sectoral Innovation System is used, with active participation of the government in regulating and developing the implementation of strategies for companies in the industry and the adoption of international environmental legal standards (Iyer, 2015).

> connectivity of refineries and reduce saturation problems, as well as engender the conditions needed to make operations more flexible and allow for the involvement of private enterprise. The challenge will be for this sector to build the aforementioned infrastructure, which it has not done optimally in the case of gas pipelines, in which it has been possible to invest since the mid-1990s.

Just like on the international stage, the choice for private companies to invest in refining is subject to whether or not they will be able to access attractive conditions for profitability. In this sense, government stimulus packages, crude price volatility, and the conditions in the petroleum products market,[34] as well as, of course, companies' operational performance, will all play a role.

In summary, the development of the Mexican refining industry will be determined by the role of private investment in reviving it. Private entities have already announced some transportation, distribution, storage, retail, and petroleum self-consumption service projects, as well as the likely construction of new refineries.[35] Pemex will also play a major role in the industry, because it will be the placeholder in the supply of petroleum byproducts, as it will have to occupy spaces that private enterprises do not wish to enter. In light of the foregoing, it would be a good idea to speed up reconversion strategies, but also to access financial support, full autonomy in decision-making,[36] and a change in the organizational culture.

CONCLUSIONS

Refining is a complex and capital-intensive business with long-term returns on investment, which requires efficiency, technology, good management, and compliance with

[34] For example, in nations operating under the free market principle, asymmetric behavior has been observed between gasoline prices in retail and wholesale, which entails implications for profit margins on retail (Brewera *et al.*, 2014).

[35] In mid-2015, an international consortium of companies in Mexico and the United States announced that it would apply for a permit to build six new refineries with an approximate cost of six billion dollars and petroleum production of nearly 360,000 bd.

[36] This is a limitation for the company, because its Management Council is composed of members of the government. Its chairman is the Secretary of Energy, who is one of the promoters of opening up the energy sector, and even worse, the federal government decides on corporate changes, which lends political overtones to the handling of the company.

environmental standards to process clean products, where the main input, crude oil, has displayed volatile prices and unique conditions related to its availability for treatment.

Despite the closure of units in developed nations, the global refining industry has surplus installed capacity, derived primarily from investments in past years in the Asia-Pacific and Middle Eastern regions, as well as upgrades in other countries. This is in a market where the consumption of petroleum products has fallen in the most developed nations and risen in all other nations, but which is headed for increased growth in the coming years, particularly as a result of the dynamic transportation industry.

The United States and Canada have increased their refining capacities by upgrading plants, but at the same time, they have closed other, less profitable plants. Their market structure is a monopolistic competitive structure. The former country records a surplus petroleum balance, and the latter is very close to equilibrium, but imports and exports due to reasons related to logistics. They both operate essentially pursuant to free market criteria with limited consumption growth. Even with Mexico's deficit, the region displays a surplus, which can be used in the case of Mexican purchases, especially because this takes place on the Gulf of Mexico where there is the infrastructure necessary for its transportation.

When it comes to Pemex, the state enterprise has managed to supply national petroleum consumption in a timely fashion with domestic production and imports. However, it is dealing with a series of structural problems throughout the entire value chain, which make it unprofitable and lead to liquidity problems and high leverage. Its operational performance has been inefficient and is marked by limited contributions of resources from the administrations in charge, which have prevented increased investment, maintenance, and upgrading of plants, or even the building of new units. This has all taken place in a context in which the priority for oil policy since the 1980s has focused on exploiting hydrocarbons, rather than on activities that add value to the crude extracted.

Consumption of oil byproducts in the country will continue to grow in the coming years, especially for light products, in a context of surplus crude oil production for at least until halfway through the next decade. With the approval of the 2013 energy reform, private initiative can now become the main actor in developing the national refining industry, but to prevent supply problems, Pemex will have to operate in the markets where private companies do not want to enter. This participation will continue to be subject to restrictions on management autonomy when it comes to strategic decisions and budgetary constraints for at least the rest of this decade, as well as the government's strategy to develop spaces for other players to make the energy reform viable. This well set the state oil enterprise on the road to either partnerships or selling assets and, of course, to losing influence over and share of the market in which it was formerly the sole player.

Table 5. Select Information on Refining Companies in North America, 2014. Billions of dollars

Item	*Pemex Refinancing*		*Valero*		*Phillips 66*			*Tesoro*		*ExxonMobil*
	2010	*2014*	*2010*	*2014*	*2010 **	*2014*	*2010*	*2014*	*2010*	*2014*
Refining capacity (mbd)	1.5			2.9	2.6	2.2	0.7	0.9	6.6	5.2
Refineries (number)	6	6	13	15	15	14	7	6	36	30
Service stations (number)	9 232	10 830	1 386	7 400	10 000	8 600	880	2 267	26 278	
Usage capacity	77 %	72%	82 %	97%	81%	94%	72 %	97%	84%	85%
Employees (number)	45 306	45 306		10 065	10 065	10 065	10 065	10 065	10 065	10 065
Net sales	49.1	51.6	82.2	130.8	146.5	161.2	20.8	40.6	370.1	394.1
Net profit	-6.7	-7.7	0.9	3.7	0.7	4.8	-0.0	872.0		35.9
Total assets	46.4	17.4	37.6	45.5	48.0	48.7	3.0	16.5	302.5	349.4
Stockholder's equity	-1.1	-19.9	15.0	21.2	20.7	22.0	3.2	7.0	152.7	181.1
Investment in refining	1.8	2.7	1.7	2.2	1.5	2.2	0.0	3.2	2.5	3.0
Operating revenue	-12.6	6.7	1.9	0.9	1.3	4.1	0.1	1.6	53.0	51.6
Net profit refining	-1.1	-7.7	0.9	3.7	4.1	1.8	0.0	872.0	3.6	32.5

Notes: mmdb: millions of dollars per day; *for number of employees and service stations, data taken from 2012. **Source:** Created by the author based on data from the annual reports of each company.

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